A TAXONOMIC STUDY OF THE GENUS *LAURENCIA* (CERAMIALES, RHODOPHYTA) FROM VIETNAM. IV. *LAURENCIA NANGII* SP. NOV.

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ABSTRACT — *Laurencia nangii* sp. nov. (Ceramiales, Rhodophyta) is described from Vietnam. It is distinguished by the following set of morphological features: 1) soft, terete axes developing from an entangled stoloniferous basal system; 2) the production of four periaxial cells from each axial cell; 3) the presence of longitudinally oriented secondary pit-connections between contiguous superficial cortical cells; 4) projecting superficial cortical cells at the upper portions of branches; 5) abundant lenticular thickenings in the walls of medullary cells, even in ultimate branches; 6) the presence of intercellular spaces between medullary cells; and 7) a parallel arrangement of tetrasporangia produced from two periaxial cells per fertile segment.

RÉSUMÉ — *Laurencia nangii* sp. nov. (Ceramiales, Rhodophyta) est décrite du Vietnam. Cette espèce se caractérise par l'ensemble des caractères suivants : 1) des axes mous, de section circulaire, se développant à partir d'un système basal stolonifère enchevêtré ; 2) la production de quatre cellules périaxiales à partir de chaque cellule axiale ; 3) la présence de synapses secondaires orientées longitudinalement, entre les cellules superficielles contiguës ; 4) des cellules corticales superficielles saillantes dans les parties apicales des rameaux ; 5) des épaississements lenticulaires abondants dans les parois des cellules médullaires, même dans les rameaux d'ordre ultime ; 6) la présence d'espaces intercellulaires entre les cellules médullaires ; et 7) une disposition des tétrasporocystes parallèle à l'axe des rameaux, ces tétrasporocystes sont produits par seulement deux des quatre cellules périaxiales de chaque segment fertile. (Traduit par la Rédaction).

KEY WORDS: Ceramiales, *Laurencia mariannensis*, *Laurencia nangii*, marine algae, new species, Rhodomelaceae, Rhodophyta, taxonomy, Vietnam.

INTRODUCTION

The red algal genus *Laurencia* (Ceramiales, Rhodomelaceae) contains small- (a few mm long) to large-sized (about 50 cm long) species, each of which has been characterised by a combination of many morphological features as reviewed by Masuda & Suzuki (1997). Relatively few species are characterised by the set of features that consists

of i) longitudinally oriented secondary pit-connections present between contiguous superficial cortical cells, ii) superficial cortical cells projecting at the upper portions of branches, and iii) lenticular thickenings present in the walls of medullary cells (Saito, 1969; Cribb, 1983; McDermid, 1988; Zhang & Xia, 1988; Masuda, 1997). In this paper a new species with the above features, *L. nangii*, is described from Vietnam. Although it is questionable that the presence or absence of lenticular thickenings has value as a diagnostic feature at the sectional level adopted originally by Yamada (1931) as pointed out by Saito & Womersley (1974), it is considered to be an important feature at the species level (Masuda *et al.*, 1992, 1996).

MATERIALS AND METHODS

About 30 specimens of a new *Laurencia* species were collected at My Hoa, Ninh Hai (20.i.1993) and Son Hai, Ninh Phuoc (21.i.1993), Ninh Thuan Province, Vietnam. About half of the specimens were fixed in 10% formalin in seawater, and others were pressed on herbarium sheets. Sections were made by hand using a razor blade and pith stick. These were stained with 0.5% (w/v) cotton blue in a lactic acid/phenol/glycerol/water (1:1:1:1) solution and mounted in 50% glycerol-seawater on microscope slides. Voucher specimens are deposited in the Herbarium of the Graduate School of Science, Hokkaido University (SAP 062413-062416).

The following herbarium specimens of *Laurencia mariannensis* Yamada deposited in SAP were examined for comparison with the alga under study: i) Saipan Island, Marianas (No. 13874, holotype specimen, date unknown) and ii) Kumejima, the Ryukyu Islands (No. 056359, 5.x.1927).

RESULTS

Laurencia nangii sp. nov.

Plantae ex axibus rectis pluribus utrinque e disco basali communi et e ramis stoloniformibus effecti constantes; thalli viridi-brunnei, molles, exsiccatione chartae firme adhaerentes; axes pricipales 3-6 cm in longitudine, omnino teretes, percurrentes, usque ad 1.2 mm in diametro, ramos numerosos in mode irregulariter spirali ferentes; rami ordinum omnium polystichi; rami ultimati clavati vel teretiusculi usque ad 1.25 mm longi et 300-700 μm lati; cellula axialis omnis cum cellulis periaxialibus quattuor; foveae-colligationes secundariae longitudinaliter dispositae inter cellulas corticales superficiales contingentes semper adsunt; cellulae corticales superficiares prope apices ramorum leviter procurrentes; incrassationes lenticulares abundantes in parietibus cellularum medullae etiam in ramulis ultimis; spatia intercellulosa inter cellulas medullosas adsunt; tetrasporangia e cellulis periaxialibus in ramis ultimis et penultimis in successione acropetali formata, igitur in ordinatione parallela ad axem longitudinalem disposita; tetrasporangia matura 100-120 μm in diametro; cystocarpia et spermatangia non inventa.

Plants consisting of several upright axes arising both from a common discoid holdfast and from stolon-like branches; thalli greenish-purple, soft, adhering firmly to

paper on drying; main axes 2-6 cm in length, terete, percurrent, up to 1.2 mm in diameter, bearing many branches in an irregularly spiral manner; branches of all orders polystichous; ultimate branches clavate or somewhat terete, up to 1.25 mm long and 300-700 μm wide; each central axial cell with four periaxial cells; longitudinally oriented secondary pit-connections always present between contiguous superficial cortical cells; superficial cortical cells slightly projecting at apices of branches; lenticular thickenings abundant in the walls of medullary cells even in ultimate branchlets; intercellular spaces present between medullary cells; tetrasporangia formed from periaxial cells on ultimate and penultimate branches in acropetal succession, therefore arranged parallel to the longitudinal axis; mature tetrasporangia 100-120 μm in diameter; cystocarps and spermatangia not found.

Holotype and type locality: SAP 062415 (Fig. 1), collected by M. Masuda on 21 January 1993, at Son Hai, Ninh Phuoc, Ninh Thuan Province, Vietnam.

Distribution: Endemic to southern Vietnam; known from Ninh Thuan Province, facing the South China Sea.

Etymology: The specific epithet is dedicated to Dr Huynh Quang Nang, National Center for Scientific Research of Vietnam, who is a leader of many projects related to utilization of seaweed resources in Vietnam.

Plants grow epiphytically on other algae including corallines and *Sargassum* sp. in the shallow subtidal zone on reef flats. Five to twelve upright axes arise both from a common discoid holdfast and from stolon-like branches which develop from the lower portions of axes and are loosely entangled with one another. Percurrent, terete main axes are 0.8-1.0 mm in diameter in the basal portions, 1.0-1.2 mm in the middle portions, and tapering gradually to 550-700 μm in the uppermost portions.

Abundant first-order branches are formed in an irregularly spiral manner 1-5 mm apart and at angles to the bearing axes of 20-60°. These first-order branches are 2-3 cm long along the lower to middle portions of the main axes and become shorter distally. They bear progressively shorter branches of up to four orders which are also arranged in an irregularly spiral manner (Fig. 2). Ultimate branches are clavate or terete, up to 1.25 mm long and 300-700 μm wide. Branches of all orders are polystichous (arranged in many rows). Adventitious branches are produced from the lower entangled portions of the thallus.

Apical cells are always immersed in an apical pit, as is typical of the genus. Axial cells are recognizable only just behind the apical cell. Each axial cell produces four periaxial cells (Fig. 3). Superficial cortical cells are polygonal and are regularly arranged in longitudinal rows. They are 10-36 μm long by 20-32 μm wide (a length: width ratio of 0.5-1.2) in surface view in distal portions of first-order branches, 40-140 μm long by 28-50 μm wide (a length:width ratio of 1.2-4.4) in middle portions, and 30-70 μm long by 24-40 μm wide (a length:width ratio of 1.0-1.9) in proximal portions.

Superficial cortical cells in transverse sections are 16-24 μm thick (a thickness: width ratio of 0.6-1.2) in distal portions of first-order branches, 30-50 μm thick (a thickness: width ratio of 0.5-1.3) in the middle portions, and 30-40 μm thick (a thickness: width ratio of 1.0-1.5) in the proximal portions. They do not form a palisade layer (Fig. 4). Longitudinally oriented secondary pit-connections are always present between contiguous superficial cortical cells (Fig. 5). Superficial cortical cells project slightly at the uppermost portions of branches (Fig. 6). Lenticular thickenings 14-30 μm thick are abundant in the walls of medullary cells (Fig. 7), even in ultimate branches. Medullary cells are 60-90 μm in diameter and have walls 2 μm thick in the proximal portions of

first-order branches. Intercellular spaces are present between medullary cells (Fig. 8). As no living material was available, presence of *corps en cerise* could not be ascertained.

Tetrasporangia are formed within ultimate (Fig. 9) and penultimate branches that reach 0.5-2 mm long by 400-600 μm wide. The tetrasporangial initial is cut off abaxially from an elongated periaxial cell (Fig. 10). Only two of the four periaxial cells elongate and produce tetrasporangia in each fertile tier (Fig. 11). Each tetrasporangium is provided with two cover cells that are distally produced by the fertile periaxial cell (Fig. 12). Tetrasporangia become mature acropetally, are arranged parallel with the long axis of the branch (Fig. 9), and reach 100-120 μm in diameter. Spermatangia and cystocarps were not found in specimens examined.

DISCUSSION

As pointed out in a previous paper (Masuda & Suzuki, 1997), approximately 25 features have been used in combination for species discrimination in the genus *Laurencia*. Species that are characterised by one particular combination of features: the presence of longitudinally oriented secondary pit-connections between contiguous superficial cortical cells; the presence of projecting superficial cortical cells at the upper portions of branches; and the presence of lenticular thickenings in the walls of medullary cells, are relatively few (Saito, 1969; Cribb, 1983; McDermid, 1988; Zhang & Xia, 1988; Masuda, 1997). The following species that have this set of features require comparison with *Laurencia nangii*: *L. caduciramulosa* Masuda *et* Kawaguchi (Masuda *et al.*, 1997), *L. decumbens* Kützing (Wynne, 1995), *L. galtsoffi* Howe (Howe, 1934; McDermid, 1988), *L. mariannensis* (Yamada, 1931; McDermid, 1988), *L. omaezakiana* Masuda (1997), *L. pannosa* Zanardini (Yamada, 1931; Masuda, unpublished observations), *L. pygmaea* Weber-van Bosse (Cribb, 1983), and *L. silvae* Zhang *et* Xia (1980 as *L. fasciculata* Zhang *et* Xia). *Laurencia caduciramulosa*, which is known only from Vietnam, is distinguished from *L. nangii* by the production of deciduous propagules (Masuda *et al.*, 1997). *Laurencia galtsoffii*, known from the Pacific, and *L. pannosa*, reported from the Pacific and Indian Ocean, differ from *L. nangii* by having strongly intricate thalli forming cushion-like or felt-like clumps (Howe, 1934; Zhang & Xia, 1985; Masuda, unpublished observations). *Laurencia omaezakiana*, which is known only from Japanese waters (Masuda, 1997), is distinguished from *L. nangii* by its distichous branching in the lower to middle compressed portions and spiral branching in the upper terete portion (Masuda, 1997). *Laurencia silvae*, reported from southern China, differs from *L. nangii* in the absence of stolon-like prostrate branches (Zhang & Xia, 1980, 1985).

Laurencia decumbens, originally described from New Caledonia (Kützing, 1865), has been characterised by the presence of lenticular thickenings and the absence of projecting superficial cortical cells (Saito, 1969). However, Wynne (1995) reported his Seychelles material from the Indian Ocean as having both lenticular thickenings and projecting superficial cortical cells. Wynne (1995) also reported a perpendicular arrangement of its tetrasporangia in his material and reduced *L. pygmaea* to be synonymous with *L. decumbens* as first proposed by Furnari & Cormaci (1990). However, *Laurencia pygmaea*, first described from Diego Garcia, the Chagos Archipelago, Indian Ocean (Weber-van Bosse, 1913), lacks projecting superficial cortical cells according to Yamada (1931) who examined the type material. On the other hand, Cribb (1983) described the Great Barrier Reef specimens of *L. pygmaea* as having projecting superficial cortical cells

and tetrasporangia arranged parallel to the parent axis. These discrepancies indicate that it is prudent to maintain *L. decumbens* and *L. pygmaea* as separate species until type specimens of the both or freshly collected specimens from their respective type localities are thoroughly compared. In spite of this problem, *L. nangii* is distinguished from *L. decumbens* and *L. pygmaea* by the absence of decumbent or prostrate axes with discoid attachments.

Laurencia mariannensis (Figs 13, 14) seems to be most similar to *L. nangii*. It was first described on the basis of material from Saipan Island, Marianas (Yamada, 1931), and has been widely reported from the tropical to subtropical regions in the Pacific: Hawaiian Islands (Saito, 1969; McDermid, 1988); Marshall Islands (Dawson, 1957); Solomon Islands (Womersley & Bailey, 1970); the Great Barrier Reef, Australia (Cribb, 1983); Caroline Islands (Taylor, 1950; Dawson, 1956); the Philippines (Saito, 1969); Xisha Islands, China (Zhang & Xia, 1985), and the Ryukyu Islands, Japan (Yamada & Tanaka, 1938). It can be distinguished from *L. nangii* by its more slender (compare Figs 13, 14 with Figs 1, 2), more delicate and pale rose-red thalli. As Yamada (1931, p. 200) did not give dimensions of axes and branches, those of the holotype specimen deposited in SAP (No. 13874) are given below. Main axes are 450-550 µm in diameter in the lower to middle portions and 200-240 µm at the uppermost portion; ultimate branches are 130-200 µm in diameter. Specimens of *L. mariannensis* collected at Kumejima, the Ryukyu Islands (SAP 056359) are similar in these dimensions to the holotype specimen.

Laurencia mariannensis reported from the above-mentioned localities is not uniform in axis width. Main axes and branches are reported to be 200 µm wide in Hawaiian (McDermid, 1988), 625-1000 µm (ultimate branches being 250-500 µm) in Australian (Cribb, 1983), 500-1000 µm in Bikini material without much decrease in size from base to apex (Taylor, 1950), and 700-1000 µm (ultimate branches being about 300 µm) in Chinese material (Zhang & Xia, 1985). Furthermore, thallus colour is reported to be pale rose-red in the holotype specimen, rose-red in Hawaiian (McDermid, 1988), and yellowish-brown slightly tinged with purple (branch apices being green) in Chinese specimens (Zhang & Xia, 1985). There is a strong possibility that *L. nangii* may have been confused with *L. mariannensis* by some authors (Taylor, 1950; Cribb, 1983; Zhang & Xia, 1985). Re-examination of material reported under the name of *L. mariannensis* are needed to clarify their status.

ACKNOWLEDGEMENTS — I am grateful to Dr Huynh Quang Nang and Dr Nguyen Huu Dinh, National Center for Scientific Research of Vietnam, for their kind help in the field. This study was supported by a grant under the Monbusho International Scientific Research Program-Field Research (No. 04041015).

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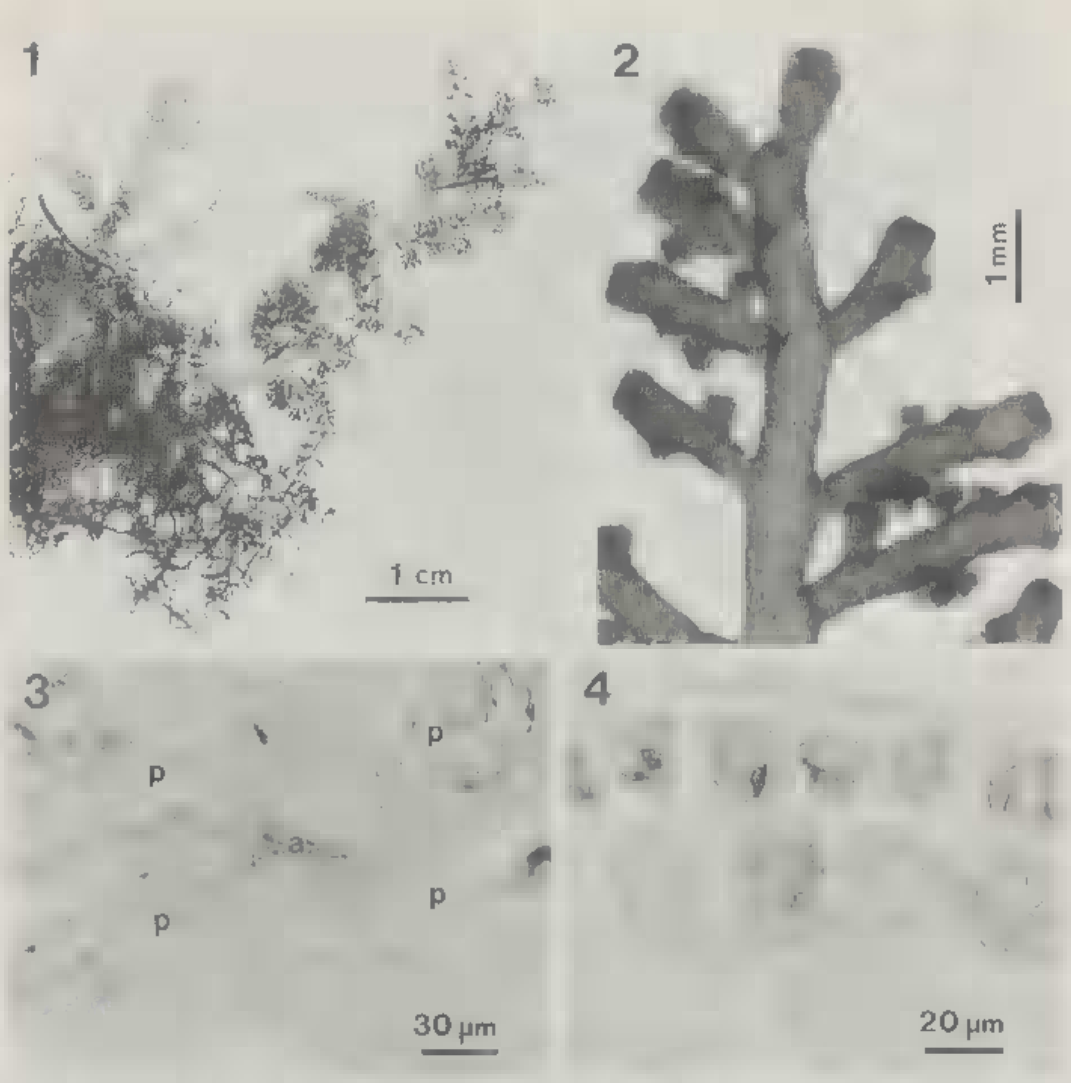
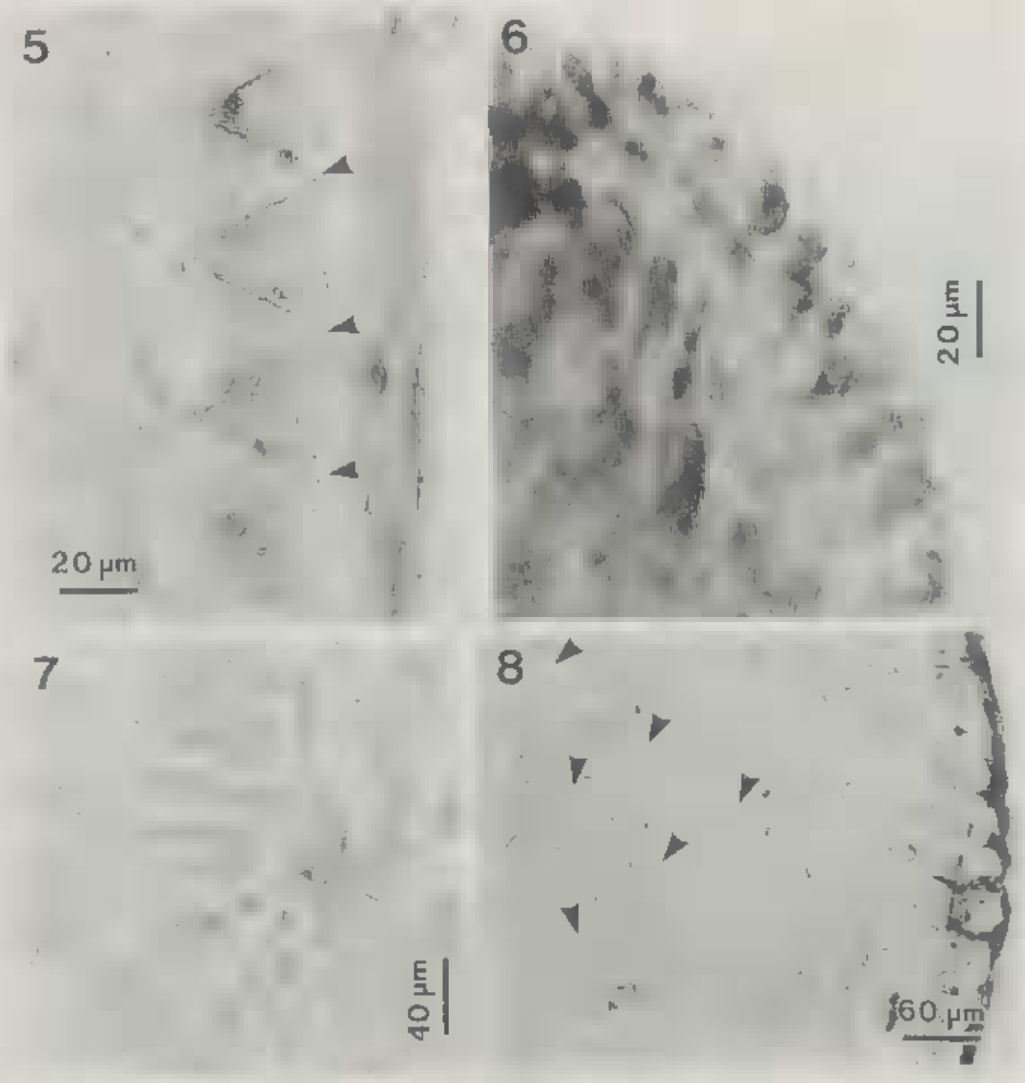
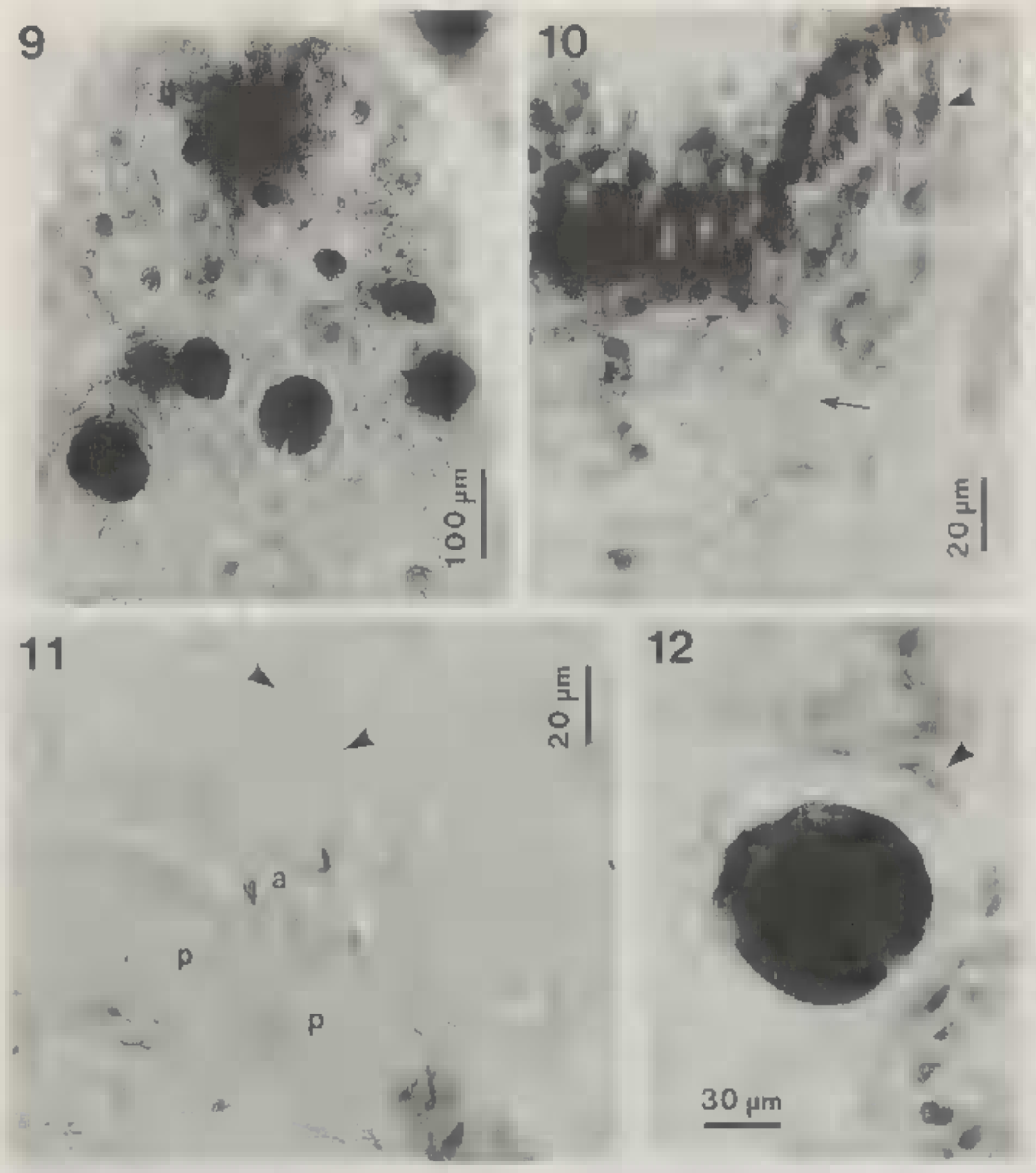


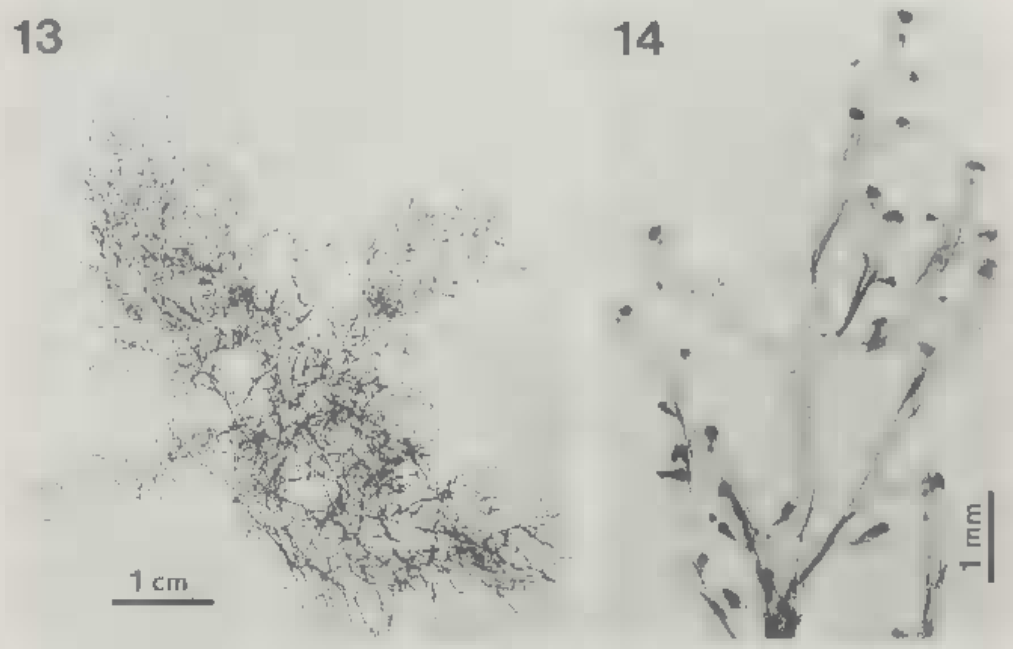
Figs 1-4. *Laurencia nangii*. Fig. 1. Holotype specimen (tetrasporangial) collected at Son Hai, Ninh Phuoc, Ninh Thuan Province, Vietnam (SAP 062415). Fig. 2. Upper portion of a first-order branch. Fig. 3. Transverse section (TS) of the upper portion of a third-order branch, showing an axial cell (a) with four periaxial cells (p). Fig. 4. TS of the upper portion of a third-order branch.



Figs 5-8. *Laurencia nangii*. Fig. 5. Longitudinal section (LS) of the middle portion of a first-order branch, showing longitudinally oriented secondary pit-connections (arrowheads) between contiguous superficial cortical cells. Fig. 6. Surface view of the uppermost portion of a second-order branch, showing projecting superficial cortical cells. Fig. 7. TS of the middle portion of a third-order branch, showing medullary cells with lenticular thickenings. Fig. 8. TS of the lower portion of a first-order branch, showing intercellular spaces (arrowheads) between medullary cells.



Figs 9-12. *Laurencia nangii*. Fig. 9. Surface view of a tetrasporangial branch. Fig. 10. LS of a tetrasporangial branch; arrowhead indicates a young tetrasporangium; arrow indicates an elongated, fertile periaxial cell. Fig. 11. TS of a tetrasporangial branch, showing an axial cell (a) with two vegetative periaxial cell (p) and two fertile periaxial cells (arrowheads). Fig. 12. LS of a tetrasporangial branch, showing a developing tetrasporangium; arrowhead indicates a cover cell (another being out of focus).



Figs 13-14. *Laurencia mariannensis*. Fig. 13. Holotype specimen collected at Saipan Island (SAP 13874). Fig. 14. Upper portion of a branch of the holotype specimen.